Advanced Greenhouse Using Hybrid Wireless Technologies

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Abstract- In order to reduce effect of climate & increase crop production we have to monitor various environmental parameters which affect the crop development. This paper consists of design & implementation of a WSN that combines to different wireless technologies. System is used to monitor the air temperature & humidity in greenhouse. Monitoring & control of greenhouse environment play an important role in greenhouse production & management. This can help farmers to understand the environmental conditions & they can adopt different methods to increase the production in greenhouse. ZigBee offers wireless connectivity of the sensors with control panel while GSM provides wide coverage. All monitored parameters are transmitted through a wireless link to cellular device for analysis. A cell phone is used instead of computer terminal keeping mind that system will be used by farmers & considering power management.

Keywords- humidity, short message service, temperature, Wireless sensor network (WSN), ZigBee.

I. INTRODUCTION

Since the traditional monitoring system has disadvantages in network cabling difficulty, maintenance costs high and node scalability, the wireless communication technology has been applied to protected agriculture. So the monitoring system based on radio frequency (RF) module, microcontroller unit (MCU) and sensor technology can provide a new way for real-time collecting greenhouse environment parameters in long-range. Recently, several wireless technologies have been used in the research of greenhouse such as Bluetooth and GPRS (General Packet Radio Service). Although these achievements may meet the requirements in specific application, there are still some shortcomings such as expensive equipment, protocol complexity and high power consumption. Also, ZigBee is another wireless technology which can be used in wireless communication effectively. It is perfect solution for low cost & low power applications. But, it has limitation of short distance communication. To resolve this problem we have combined two different wireless technologies in one system which uses advantages of two different wireless technologies i.e., ZigBee & GSM.

Greenhouse is a kind of advanced horticultural facility controlling and simulating natural climate in plant cultivation, changing the plant growth environment, and creating the suitable conditions for plant growth, avoiding the outside season change and the adverse effects caused by bad weather. With the development of installation agriculture, the modern large-scale greenhouse has been widely used in the precision agriculture. The need of its environment quality has become higher and higher. Greenhouse is playing an important role in the production of out-of-season vegetables and flowers, as well as high value and delicate plants [1][2]. The purpose of greenhouse environmental control is to get the best conditions for crop growth, increase crop yields, improve quality of crops, and regulate the growth cycle of crops, through changing environmental factors such as temperature, humidity & light.

One example of sensor network using two different technologies is automatic meter reading system [3]. Here ZigBee module is connected to each customer’s meter. The GSM module takes data from the ZigBee modules which are in its range and transfer it to central computer. Another example is wireless sensor network deployed in crop field [4]. Temperature, humidity & light intensity in brinjal field is sensed by different sensor nodes deployed in field. This data is transferred to centralize computer for monitoring purpose.

In this work, wireless sensor network has been implemented, that can monitor the air temperature, humidity and ambient light intensity in a crop field. Continuous monitoring of these key environmental variables can help farmers in improving the quality and productivity of crops. The design also includes implementation of necessary network services, power management, status monitoring of sensor nodes & remote data access.

The design is based on integration of two different wireless technologies for increasing the wireless range & for reducing the cost. There are different points at
which sensors are deployed in greenhouse so that area gets increased. Increase number of measurement points should not dramatically increase the system cost.

The remainder of this paper is organized is as follows: Section II presents the system architecture of WSN describing the functionality of individual components & how they operate together. Section III represents the sensor nodes design. Section IV is for Coordinator node design. Section V provides result & discussion. Section VI provides the concluding remarks & outlines the future work.

II. SYSTEM ARCHITECTURE

Fig. 1 shows hybrid wireless sensor network topology implemented in greenhouse. There are total three sensor nodes, each sensing temperature & humidity in addition to general purpose computing & networking. The computation module on each sensor node is a programmable unit that performs computation & bidirectional communication with other sensor node. It interfaces with the digital sensors on the sensor module & dispatches the data according to the application needs. Since the wireless communication range provided by the radio frequency (RF) module is more than 1000m, the sensor node can be widely separated. Sensor node 1 & sensor node 2 transmit their data through the wireless communication link to sensor node 3 which acts as a coordinator node. The coordinator node aggregates the data in time multiplexed manner, which helps in avoiding collision of data transmission. Coordinator node also acts as a gateway node between two different wireless technologies. The advantage of making node 3 as a coordinator as well as gateway node is to increase area covered by system. It transmits its collected data along with its own data to the cell phone using short message service (SMS). The cell phone is used instead of computer terminal to increase the distance, to create simplicity in the network as well as to minimize the power consumption.

III. SENSOR NODE DESIGN

The network formed consists of three nodes where each sensor node consists of small size sensor & general purpose computing elements. The sensor nodes can be deployed at various locations in a greenhouse to monitor environmental changes. The main components in sensor node are outlined below:

A. ZigBee module

ZigBee is intended for wireless application that requires low data rate, low power consumption, low cost, and secure networking. ZigBee layered on top of IEEE 802.15.4 standard which defines the physical (PHY) layer and Medium Access Control (MAC) layer. ZigBee Alliance itself defines the application and security layer specifications. The stack can be drawn in fig 2. The IEEE 802.15.4/ZigBee standard defines dual PHY layer, which are 2.4 GHz and 868/915 MHz.

ZigBee-Pro (RF) transceiver module designed by Digi provides a complete wireless networking solution serving the 2.4GHz unlicensed industrial, scientific, and medical short-range wireless frequency band for the IEEE 802.15.4™ specification, for ZigBee®, or proprietary wireless-protocol systems & provide a wireless communication range of 1000 meters in open space. The surface mount module is designed for use with a variety of 8-bit, 16-bit, and 32-bit microcontrollers (MCUs). The modules are programmed using dedicated programming kit to make them compatible for wireless communication.

B. Sensor

Sensor used for this system is for temperature & humidity measurement. Sensor description is as follows:

a. SHT15:

Small size, low power consumption, easy integration & replacement makes sensirion SHT15 [5] a perfect solution for greenhouse. It is the temperature &
humidity sensor which provides digital output to microcontroller. Temperature & humidity accuracy of the sensor is ± 0.4°C & 0.2% respectively.

This sensor does not require any external components for signal conditioning which saves valuable PCB area. Also, due to the digital nature, output is more immune to noise & external disturbances. The start-up time in sensor is very low. Therefore current is not needed for a long time during initialization thereby reducing the power consumed. The power saved can be used to perform other computing task. Another advantage is that sensor can be deployed quickly in greenhouse since no calibration is required.

B. Sensor node

The basic model of the sensor node 1 & node 2 is shown in fig. 3. Each sensor consists of SHT15 temperature humidity multi-sensor module which monitors the environmental variables in the greenhouse. Sensor is soldered to the PCB along with necessary passive components such as resistors & capacitors. The sensor node operates as a basic measuring node with RF transceiver & AVR ATmega16L controller operating at 1MHz. The microcontroller acts as a CPU & performs all the computations & input-output operations required for the working of sensor node. Sensor is integrated with the microcontroller through two general-purpose input-output pins. One is bidirectional for exchanging data between microcontroller & sensor & other is for providing clock to the sensor.

IV. COORDINATOR NODE DESIGN

Coordinator node acts as a sensor node as well as gateway node. It receives the data from other sensor nodes using RF communication link. It also contains SHT15 which is used to measure temperature & humidity. It acts as a gateway node because it connects two different wireless technologies as shown in fig. 4. It transmits its own data along with other sensor node’s data through GSM module to cell phone.

A sensor node data is transferred to microcontroller through UART interface. Microcontroller performs all the processing of data which is collected from sensor nodes 1 & 2. It also processes & combines the data of its own along with the data gather from node 1 & 2 while transmitting. The data is transmitted with the SMS service provided in GSM module. The main components in sensor node are outlined below:

Figure 3. Basic Model of Sensor Node

A. AVR microcontroller:

ATmega16L microcontrollers are 8-bit microcontrollers. AVR microcontroller has Harvard architecture. In Harvard architecture, we have separate buses for data & code which increases the processing speed of CPU. Also, AVR microcontroller has adopted RISC architecture. RISC architecture has many features like fixed instruction set, large numbers of registers, small instruction set & many more.

B. GSM module

GSM stands for Global System for Mobile communication. In 1982, Group Special Mobile was formed among Europe countries. This group standardized cellular communication protocol which we know as the Global System for Mobile communication nowadays. Most GSM networks in the world operate in 900 MHz or 1800 MHz bands. However, some countries are using different frequency since the allocated frequency had already been used. GSM use Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) for multiple access method and use Gaussian Minimum Shift Keying (GMSK) for its modulation method.

C. Short message service

Short message service (sms) provided by GSM is used here for sending the data to the observer for analysis. Short message service is a mechanism of delivery of short messages over the mobile networks. The short message service is realized by the use of the Mobile Application Part (MAP) of SS7 protocol. Messages are sent to a short message service centre (SMSC) which provides a ‘stored & forward’ mechanism. It attempts to send messages to SMSC’s recipients. If a recipient is not reachable, the SMSC queues the message for latter retry. SMS is send by GSM module each after 1 hour. This frequency of
sending messages can be changed according to requirement.

D. Power supply

Monitoring of the environmental behavior should be done for duration of complete season. Power supply to sensor node is provided with 3.3 V DC & 220 mA. Step down transformer is used to convert AC mains supply to DC. The power supply unit is integrated with the sensor node board. To withstand the variable weather conditions, the entire sensor node board is mounted in an acrylic enclosure that does not affect the sensing functionality. Since an acrylic covering is transparent to infrared & radio frequency, it does not obstruct the wireless communication.

E. Reliability

The short message service provided by the GSM is the most reliable system. Even if the cellular device is out of range all the messages are delivered along with time information when it comes in range.

F. User friendly system

Nowadays every individual is familiar with cell phones. Hence, it is better to use cell phones instead of any other device as displaying purpose. It also saves the energy consumed by bulky system because energy consumed by overall system including cell phone is very less.

V. RESULT & DISCUSSION

The proposed WSN system consisting of 3 sensor nodes has been tested. Fig. 5 shows a one sensor node out of three sensor nodes. Each sensor node measures temperature & humidity. Node 1 & node 2 transmits their data to sensor node 3 which combines its data with received data & transmits all data to cell phone for observation purpose. LCD display is mounted on each sensor node to measure corresponding node data as well as verification purpose.

The 3 sensor nodes are deployed in greenhouse at three different points. The temperature and humidity values measured by the 3 sensor nodes are shown in Fig. 6. The outdoor wireless communication range of a ZigBee-Pro module is 1000 m.

VI. CONCLUSION

Combination of two different wireless technologies increases the communication distance. Wireless monitoring of environmental parameters make this system effective in greenhouse. It also overcomes the limitations of traditional monitoring systems. System designed using different sensors having capability to measure different types of environmental parameters are beneficial in greenhouse. It helps farmers to increase the crop production with better quality.

REFERENCES


